CALIFORNIA DIVISION OF MINES AND GEOLOGY
FAULT EVALUATION REPORT FER-197

GROUND CRACKS ALONG THE GARLOCK FAULT ZONE IN FREMONT VALLEY, KERN COUNTY, CALIFORNIA

by

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INTRODUCTION

The Garlock fault is a major, active, left-lateral strike-slip fault that separates the Basin and Range geologic province on the north from the Mojave Desert province to the south. Quaternary traces of the Garlock fault on the SE¼ Cross Mountain 15-minute quadrangle and the Cantil 7.5-minute were zoned for special studies in 1976 (CDMG, 1976) under the Alquist-Priolo Special Studies Zones act of 1972 (Hart, 1988). Traces of the Garlock fault were based solely on the work of others--mainly Clark (1973), supplemented by mapping of Dibblee (1952) on the Cantil quadrangle and Samsel (1962) on the SE¼ Cross Mountain 15-minute quadrangle (now the Cinco 7.5-minute quadrangle). Pampeyan, Holzer and Clark (1988) have re-mapped active traces of the Garlock fault and mapped ground cracks which have formed since Clark's original mapping (1973). Many of the ground cracks have formed outside the existing Special Studies Zones boundaries (Fig. 2a & 2b). Two of these ground cracks extended into subdivisions being developed in the western Fremont Valley. The mapped fault features and ground cracks are evaluated here for zoning under the Alquist-Priolo Special Studies Zones Act. The criteria for zoning have been modified since 1976; Quaternary faults which were zoned in 1976 may not meet the more recent criteria of "sufficiently active and well-defined" (Hart, 1988). Zoned faults which do not meet the present criteria for zoning (Holocene active and well-defined) are recommended for removal from Special Studies Zones.

SUMMARY OF AVAILABLE DATA

Garlock fault and Fremont Valley ground cracks

The Garlock fault forms the northern boundary of the Mojave Desert physiographic province for over 250 km from the San Andreas fault on the west to the Death Valley fault zone on the east. The Garlock fault zone is clearly active with abundant geomorphic evidence of Holocene left-lateral strike-slip displacement (Clark, 1973).

Portions of the Garlock fault zone on the Cinco and Cantil quadrangle were mapped by Clark (1973), Samsel (1962), and Dibblee

(1952) (Figures 2a and 2b). In Fremont Valley, the fault zone makes a large left step across the deep, alluvial basin (Figure 1). Normal faults, generally with displacements down toward the center of the basin, are distributed across the basin. The pull-apart basin formed by this left step in the fault has been filled in by approximately 3200 m of Cenozoic sediments (Mabey, 1961).

Pumping of groundwater from the upper, unconsolidated sediments for irrigation has resulted in subsidence of up to 0.9m between 1977 and 1985 (Pampeyan and others, 1988). Subsidence has been accompanied by both vertical offset of the ground surface and formation of extensional fissures.

Pampeyan and others (1988) have mapped the ground cracks (Figures 2a and b) and have documented the amount and sense of movement. Ground failures mapped by Clark (in Pampeyan and others, 1988) include scarps, cracks, fissures, aligned pits and sinks, and vegetation lineaments. Scarps up to 1.6 m high and fissures up to 5 m wide have been mapped. Many of these features are outside of existing Special Studies Zones. All lie within the area of groundwater withdrawal. Offsets of the ground surface have been shown to slow, or even reverse locally during seasonal groundwater recharge. Pampeyan and others conclude that groundwater withdrawal has caused the ground failure but that ground failure, has been localized along existing faults. Therefore, a tectonic component of movement cannot be completely ruled out.

Geomorphology suggestive of Holocene faulting was also mapped by Clark (Pampeyan and others, 1988), who revised and extended his earlier work (Clark, 1973). Revisions include remapping of scarps at locality 1, remapping of fissures at locality 3, and removal of a stream-modified scarp at locality 2 (Figure 2b). Most of the geomorphic features not related to groundwater withdrawal remapped by Pampeyan and others are within existing special studies zones.

The northerly scarp at locality 1, however, extends beyond the existing zone boundary.

El Paso fault

The El Paso fault splays off from the Garlock fault and bounds the north side of Fremont Valley in the Cantil quadrangle (Figure 1). Dibblee (1952) mapped it as a normal fault with down-to-the-south movement. The fault is shown as concealed or inferred in Quaternary alluvium. Pampeyan and others (1988) have mapped short, discontinuous faults that offset alluvial fan surfaces and are delineated by generally south-facing scarps (Figure 2b). Pampeyan and others interpret these scarps to be evidence of Holocene displacement on the El Paso fault.

INTERPRETATION OF AERIAL PHOTOGRAPHS

Garlock fault and Fremont Valley ground cracks

Geomorphic features mapped by Pampeyan and others (1988) were checked on air photos, particularly where they extended beyond or were entirely outside of existing Special Studies Zone boundaries. Fissures mapped by Pampeyan and others were also checked on air photos. No field checking was done for this study. The available 1:20,000 scale photos taken by the USDA in 1952 and by the BLM in 1982 did not show all of the features mapped by Pampeyan and others, who used larger scale photos and performed extensive field investigations. Geomorphic features along the north side of the Fremont Valley were checked on 1:13,000 scale photos taken by the USGS in 1966. These photos do not cover the area of ground cracks.

Faults verified by scarps and tonal lineaments in Holocene alluvium on available aerial photos are marked with a checkmark on Figures 2a and 2b. Features that are not verified as Holocene are marked NV. Fissures are shown by the dates they were observed by Pampeyan and others (Figures 2a and 2b). Additional geomorphic features, not mapped by Pampeyan and others, were observed on aerial photographs by W.A. Bryant and this writer. (Figures 2a and 2b). These features are generally less well defined than those mapped by Pampeyan and others but several connect or extend the previously mapped faults.

Strands of the Garlock fault zone mapped by Samsel (1962) generally are expressed only as fault-line geomorphology (Figure 2a). Portions of the Garlock fault as mapped by Samsel, which do show evidence of Holocene movement, coincide with traces mapped by Pampeyan and others (1988). Similarly, the main trace of the Garlock fault was mapped by Dibblee (1952) on the Cantil quadrangle as a concealed or inferred fault beneath Quaternary alluvium. Holocene features mapped by Clark (1973) and Pampeyan and others (1988) generally follow the inferred trace of Dibblee.

El Paso fault

Dibblee (1952) mapped the El Paso fault bounding the north side of Fremont Valley (Figure 2b). He shows it as concealed or inferred beneath Quaternary alluvium. Scarps mapped by Pampeyan and others (1988) along the El Paso fault are generally short, discontinuous features in older alluvium. The eroded appearance of the scarps on aerial photos and the discontinuous nature of the zone both indicate that the El Paso fault is far less active than the Garlock. The absence of scarps on the larger, more active alluvial fans or on the active portions of the smaller fans indicate low or no slip in Holocene time.

SEISMICITY

Seismicity in the Fremont Valley area is broadly clustered around the Garlock fault on the Cantil quadrangle. Many minor earthquakes of Magnitude 1 to Magnitude 3 are recorded in the Caltech catalog (Caltech, 1985). Although this seismicity is related to the Garlock fault some may also be occurring on or near the El Paso fault.

CONCLUSIONS

Garlock fault and Fremont Valley ground cracks

Ground cracks, scarps and fissures have continued to form along the Garlock fault zone in Fremont Valley since Special Studies Zones were established in 1976. Many of the cracks have extended beyond or occurred outside of Special Studies Zones boundaries. Pampeyan and others (1988) have mapped these cracks in detail and have shown that they are due to groundwater withdrawal. Many of the fissures and vertical offsets are occurring along previously existing strands of the active Garlock fault.

Additional Holocene faults have also been mapped by Pampeyan and others. Revisions of Clark's (1973) mapping by Pampeyan and others at localities 1 and 3, Figure 2b, reflect improved location with continued investigation. Lack of verification of the scarp at locality 2 reflects a more conservative interpretation of this erosionally modified feature by Pampeyan and others. However, despite the erosional modifications, this scarp does appear to represent a fault that is well defined. Connections and extensions of faults mapped for this study are generally rather poorly defined but occur in alluvium that may be of late Holocene age and connect traces mapped by Pampeyan and others . Other faults of the Garlock zone mapped by Samsel (1962) and Dibblee (1952) do not show geomorphic evidence of Holocene movement.

El Paso fault

Short, discontinuous faults delineated by generally south-facing scarps have been mapped by Pampeyan and others (1988) along the El Paso fault. These faults offset older alluvium along the base of the El Paso Mountains. Holocene alluvium does not appear to be offset. The generally degraded appearance of the scarps, as seen on aerial photographs, indicates that most are probably not of Holocene age although minor Holocene activity cannot be ruled out. There is no evidence that the El Paso fault is a through-going surface feature.

RECOMMENDATIONS

Garlock fault and Fremont Valley ground cracks

Ground failures and Holocene faults shown on figures 2a and 2b should be included in Alquist-Priolo Special Studies Zones. On the Cinco and Cantil quadrangles (Figure 2b), zones should be revised to include the newly mapped features based on Pampeyan and others (1988) plus connections and extensions mapped for this report. The main traces mapped by Dibblee (1952) and Samsel (1962) should be removed from the Special Studies zones map. Dates on fault rupture shown on the existing Special Studies Zones Map of the Cantil quadrangle refer to the first observation of rupture features due to progressive deformation (creep). The dates should be replaced with the symbol C. References on the Cinco and Cantil quadrangles should be Clark (1973), Pampeyan and others (1988), and this FER.

El Paso fault

The El Paso fault exhibits limited, inconclusive evidence for Holocene activity. Short, discontinuous faults offset older portions of alluvial fans in a broad area roughly following the El Paso fault. These minor faults and the El Paso fault of Dibblee (1952) are not recommended for zoning.

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Earl W. Hart
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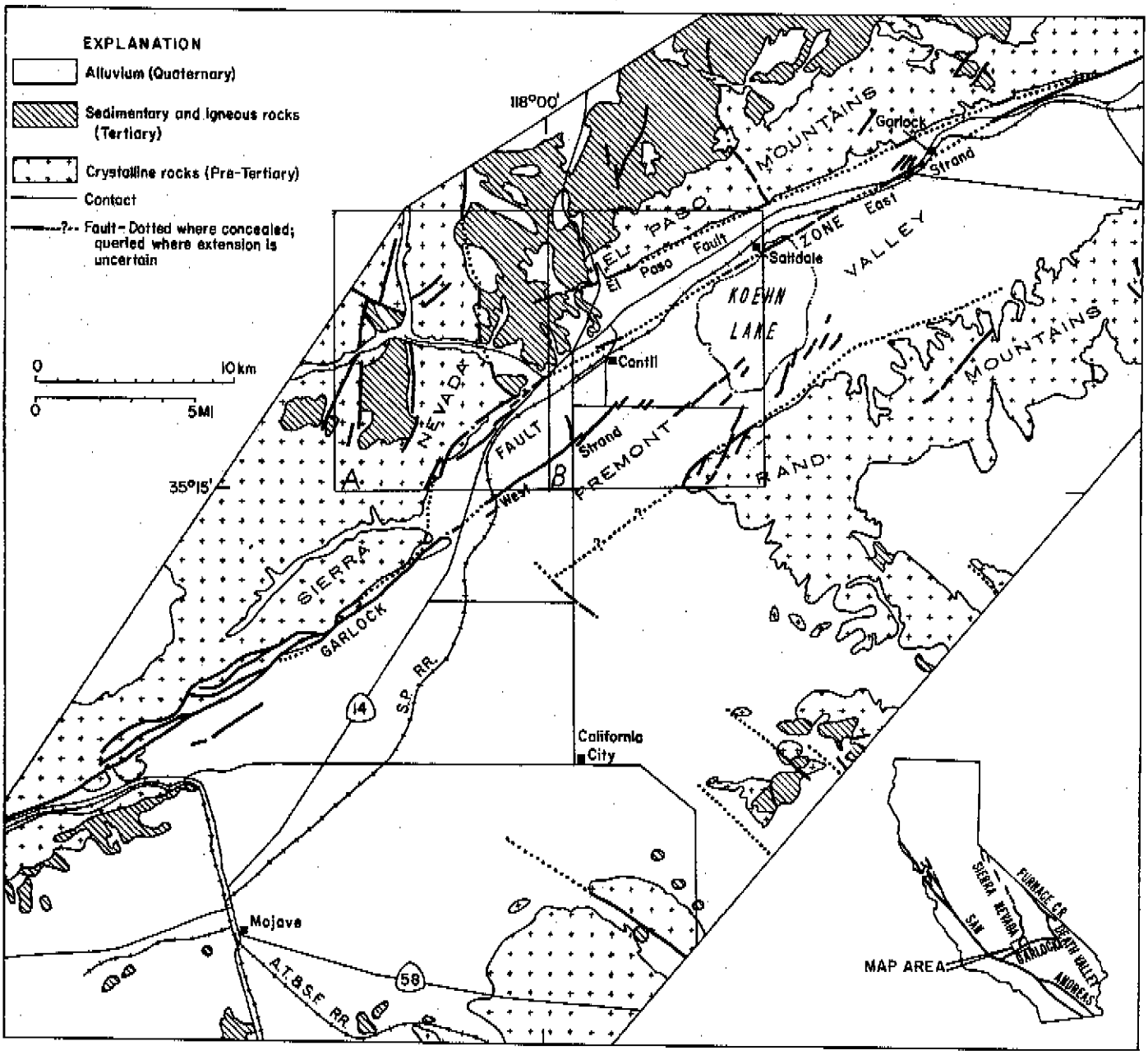

FER 197, Figure 1. Generalized geologic map of the Fremont Valley area from Pampeyan and others (1988) with locations of Cinco (A) and Cantil (B) quadrangles.